

Analysis of Flood Hazards on Urban Infrastructure in Minna City of Niger State, Nigeria

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Abstract

Hazard vulnerability and damages in terms of flooding affects housing, cars, roads, bridges and other assets in Minna. As more and more settlements were spreading in low-lying flood prone areas, they were becoming more exposed to physical vulnerability in Minna. This study aimed at examining the level of hazard vulnerability and extent of damages in relation to properties and infrastructure when flood occurs in Minna and suggests possible mitigating measures for disaster in Minna. Research design method was explored. The study population comprised of flood victims of IDPs camp in Minna which is 638. The sample-size for the study was 144. Purposive random sampling technique was used. The researcher designed a structured questionnaire. Focus group discussion and interview were used to collect factual information from 2012 to 2021 for data analysis. Mean statistic, t-test and ANOVA were used as methods of data analysis. The result of the study revealed that floods constituted an integral part of hazard vulnerability in Minna. It is evidently clear that when flood occurs in Minna countless losses are recorded. Therefore, actions to regulate floods disaster in Minna must be pragmatic to mitigate flood events in Minna since the prediction of severe flooding had been established in the study.

Keywords: Analysis, City, Hazard Vulnerability, Mitigate Flood, Urban Infrastructure.

Introduction

The study was on Analysis of Flood Hazards on Urban Infrastructure in Minna City of Niger State, Nigeria. The most vulnerable groups in Minna, typically living in poverty, tend to settle and build homes in unsafe (informal) locations and are without adequate provision of infrastructure and critical services. The urban poor are particularly vulnerable to climate change and natural hazards due to their location within cities, and the lack of reliable basic services (GFDRR, 2014). Vulnerability varies from place to place, and the degree of correlation impacts policy implementation directly (Bera & Daněš, 2018). However, floods are among the most devastating natural hazards in the world, claiming more lives and causing more property damage than any other natural phenomena (World Bank, 2014). Hence flooding in Minna needs to be analyzed. Africa's urban population is expected to almost triple from 548 million in 2018 to around 1.5 billion in 2050 (UN, 2018). Rapid urbanisation of the city over the past 20 years has led to a significant increase in flood risk. The engagement with risk communities at the commencement of and throughout flood modelling and mapping activities has led to a more accurate depiction of the urban flood risk than would otherwise have been achieved (Gebremedhin *et al.*, 2020). Urban flooding

is usually much more damaging because of higher concentration of assets and population making management of the situation more costly and complex (Pereira *et al.*, 2017; Diakakis *et al.*, 2017).

The vulnerability of urban flooding is enhanced by the increased unplanned growth of population. Due to small drainage basins in most of the urban centres, vulnerability impacts on the society are substantial (Hardy *et al.*, 2016). Therefore, there was a need for an integrated approach to assessing vulnerability including both physical and social dimensions, (Karagiorgos, *et. al.*, 2016), to the identified scenarios of flood vulnerability. The road flooding depended upon precipitation, timing and intensity of flooding, drainage situation and topographic characteristics (Yin *et al.*, 2016). When roads were disrupted due to flood, trapping or rise of open water in cars and other vehicles caused flood casualties (Dorbot & Parkar, 2007). Road mobility exposure during floods was much larger than residential exposure in urban locations (Debionne *et al.*, 2016). Not only residential houses and roads but also destruction of temples, mosques and educational institutions was caused by floods (Dewan, 2015).

Statement of Research Problems

Uncontrolled urbanization and rapid population growth, without the expansion of the necessary infrastructure to address it, will exacerbate the destructive force of natural disasters. Nigeria is now about half urban, and the population is expected to grow from over 200 million people to perhaps 450 million by mid-century. In the last three decades, the impacts of flooding have increasingly assumed from significant to threatening proportions, resulting in loss of lives and properties. Though detailed statistics are not available regarding the losses sustained by the urban dwellers and flood victims, it is obvious from the available record that irreparable havocs have been sustained by the citizen of Nigeria due to what has become perennial natural disaster in our cities. The urban poor are particularly vulnerable to climate change and natural hazards due to their location within cities, and the lack of reliable basic services (GFDRR, 2014). It is in view of this that the researchers conceived the study. The increase in extreme floods throughout West Africa is a call for countries to refocus on efforts on flood prevention and preparedness. The recovery and reconstruction process is an opportunity for Nigerian government to develop stronger preparedness planning and to rebuild long-term disaster resilience not just the response (World Bank, 2014) the common types of disasters in Nigeria are floods, drought, oil spill, bush fire and landslide. However, the Analysis of Flood Hazards is a way for determining the level of hazard vulnerability, extent of damages, after a natural disaster through a government-led process. In view of the aforementioned, the researchers were motivated to Analyse Flood Hazards on Urban Infrastructure in Minna City of Niger State, Nigeria.

Objectives

The study aimed at achieving the following:

Examine the level of hazard vulnerability and extent of damages in relation to properties and infrastructure when flood occurs in Minna and Suggest possible mitigating measures for disaster in Minna.

Literature Review

To provide a better understanding of flood hazard management, flood vulnerability assessment is the primary objective. Data on hazards, exposures, vulnerabilities and losses enhance the accuracy of risk assessment, contributing to more effective measures to prevent, prepare for and financially manage disaster risk (OECD, 2012). Modern approaches to risk assessment include risk modeling which came into being when computational resources became more powerful and available (GFDRR, 2014a). Risk models allow us to simulate the outcomes and likelihood of different events. Flood disasters struck numerous people in 2000, 2007, 2014, and 2015. Between 2010 and 2020, almost 3.6 billion inhabitants were inundated, comprising 56 percent of the world's total population. During 2010–2020, about 820,000 people in South and North America alone suffered from flood hazards (Rehman et al., 2019). The tragedy is limited to developed countries and significantly impacts the world's most urbanised and developed nations. In 1988–2000 significant damage and economic losses of USD 3.64 trillion were caused in Central America and Asia due to natural and manmade disasters (Andrade & Szlafsztain, 2018). Andrew Hurricane in America has caused losses of around \$ 27 billion (Aroca-Jiménez et al., 2020). Flood damages and their potent effects on people should also be considered when locating the case. Highly populated cities are more likely to suffer from flooding, and the impact is different from the asset (Bajracharya et al., 2021). Floods have led to tremendous losses of property, infrastructure, business and increased risk of diseases. For example, the Ogunpa flood, which occurred in Ibadan in 2011, resulted in a tremendous number of casualties. It was documented that about 25% of households in Ibadan lost their livelihoods, as their businesses were adversely affected (WHO, 2012). Similar to Ogunpa were floods in the states along the rivers Niger and Benue in 2012 and 2017, Lagos in 2011, 2012 and 2017 as well as the Niger Delta regions in 2012. The Niger River at Lokoja city, Kogi state, has not receded, as it recorded water levels of 11.05m on 24 September (NEMA, 2018).

Risk assessments are produced in order to estimate possible economic, infrastructure, and social impacts arising from a particular hazard or multiple hazards (GFDRR, 2014b). The components of assessing risk (and the associated losses) include: Hazard is defined as the probability of experiencing a certain intensity of hazard (example: Earthquake, cyclone) at a specific location and is usually determined by an historical or user-defined scenario, probabilistic hazard assessment, or other method. Some hazard modules can include secondary perils (such as soil liquefaction or fires caused by earthquakes or storm surge associated with a cyclone). The need to understand the vulnerability of floods arises because of flood natural hazards assessment and evaluation, which will contribute to effective flood control and reduce its effect on different sectors of society (Lianxiao &

Morimoto, 2019). Vulnerability is a phenomenon that emerged in the social sciences and is now becoming more common in disaster studies (Liu et al., 2021). Exposure represents the stock of property and infrastructure exposed to a hazard, and it can include socioeconomic factors. Vulnerability accounts for the susceptibility to damage of the assets exposed to the forces generated by the hazard. Fragility and vulnerability functions estimate the damage ratio and consequent loss respectively, and/or the social cost (e.g., number of injured, homeless, and killed) generated by a hazard, according to a specified exposure. (GFDRR, 2014b), The use of geographically based modelling to predict the probability of flood danger and flood damage is a deterministic approach to flood risk, contributing to flooding risk's economic effects in an area (Mohanty & Simonovic, 2021). Different techniques have been used to measure flood vulnerability for a long time (Rehman et al., 2019). Therefore, precise comparative assessment is vital for other dimensions (Andrade & Szlafsztajn, 2018). Previous studies indicated various methods used to assess the vulnerability. These methods include the vulnerability curve method, Indicator based method, analytical hierarchy process, mapping method, disaster loss data method, and modelling methods through geographic information system (Ebert et al., 2009), (Musa & Shabu, 2019) (Abid et al., 2021a, b, c).

Modern approaches to risk assessment include risk modeling which came into being when computational resources became more powerful and available (GFDRR, 2014a). Furthermore, when performed at the national level, risk assessments range from qualitative national risk profiles for advocacy purposes to the quantitative assessment of risk to inform countries financial strategies for addressing the accumulating risks. Different types of risk assessment are applied at different scales.

Table 2.1 Types of Risk Assessments

Product	Purpose	Scale	Data requirements	Cost
Community-based disaster risk assessment	To engage communities, communicate risk, and promote local action	Community level	Low: typically based on historical disaster events	<\$100,000
Asset-level risk assessments, including cost-benefit and	To inform design of building-level/asset-level risk reduction activities and	Building/infrastructure levels	Moderate-high: requires high-resolution local data for large spatial areas with clear articulation	100,000 to \$500,000;

engineering analysis	promote avoidance of new risk			
Catastrophic risk assessment for financial planning	For financial and fiscal assessment of disasters and to catalyze catastrophe risk insurance market growth	National to multi-country	High: Requires high-resolution, high-quality data of uncertainty	>\$500,000
Source: World Bank and GFDRR 2013, adapted from GFDRR (2014a)				

Methodology

The population of the study comprised of flood victims of IDPs camp in Minna. The population figure is 638. The sample-size for the study was 144. Purposive random sampling technique was used. Structured questionnaire was designed by the researcher. Focus group discussion and interview were used to collect factual information from 2012 to 2021 for data analysis. Mean statistic, t-test and ANOVA were used as methods of data analysis.

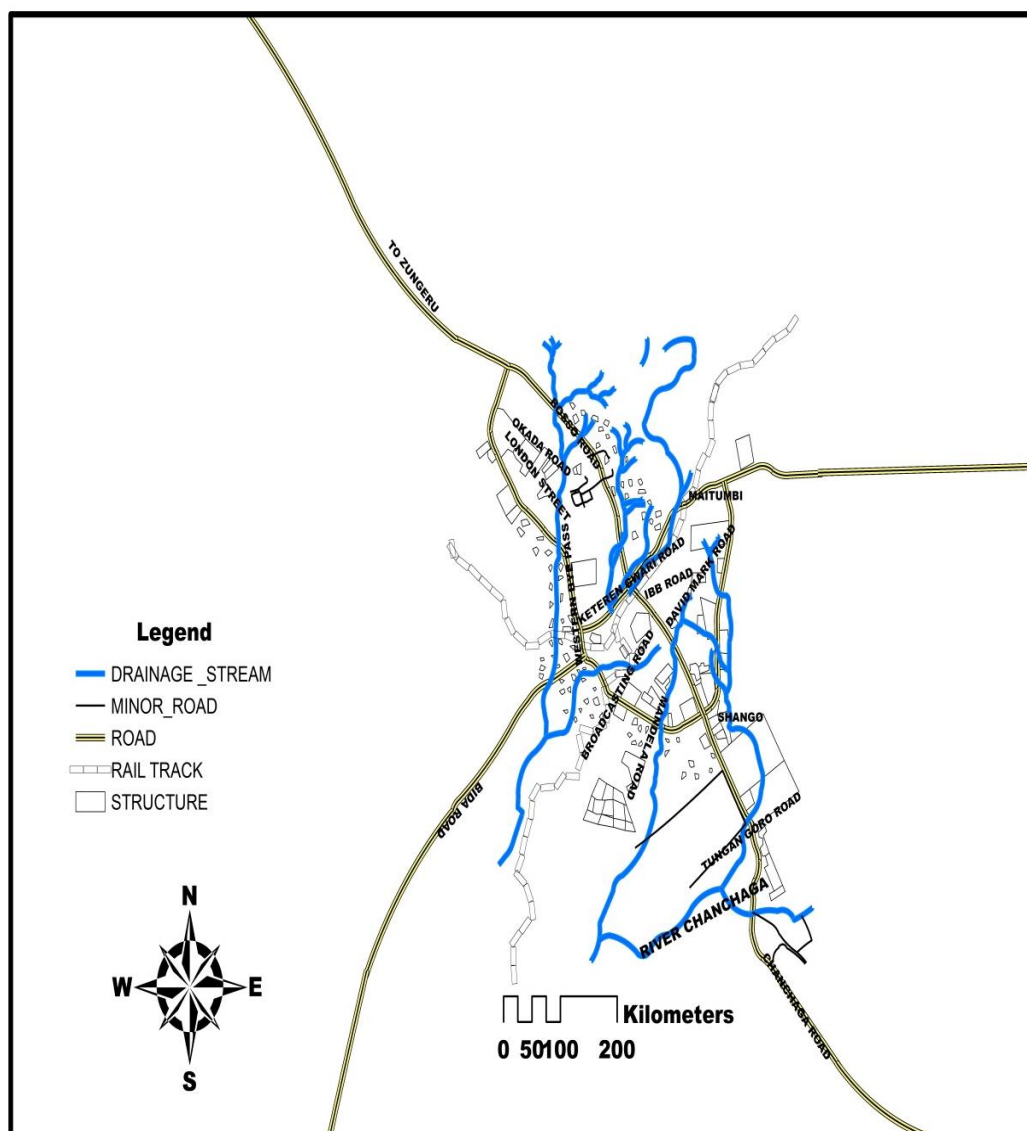


Figure1: Showing the Map of Minna Town Drainage pattern

Source: Diva-GIS

Findings

Location of Respondents

From the copies of the questionnaire distributed to respondents residing in the location of communities highlighted in Table 4.4, 125 out of 144 respondents constituted 87% of the questionnaire that were fully completed and used for the research analysis while the remaining 13% of the distributed questionnaire were not returned by some of the respondents.

Table 1: Details of Questionnaire Administered to the Respondents according to Location in Minna

Descriptio n	Chancha ga	Bosso/ Maikunke le	Kpakungu/Bari kin Sale	Dutsen Kura/Badha go Village	UngwanD aji	Paida- New Market/ Flaming o	Tot al
No.	24	24	24	24	24	24	144
Distributed	23	20	20	22	20	20	125
No Retrieved Percentage	18%	16%	16%	18%	16%	16%	100 %

Source: Field Survey, 2022

Hypothesis Tests

H₀₁: There is difference between male and female respondents on the level of hazard vulnerability in relation to the extent of damage on properties and infrastructure when flood occurs in Minna.

Table 1a: T-test on Case Processing Summary on the extent of damage on lives, crops and roads when it occurs in Minna

	Gender	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Level of hazard vulnerability in relation to the extent of damages on lives, crops and roads.	Male	10	100.0%	0	0.0%	10	100.0%
	Female	10	100.0%	0	0.0%	10	100.0%

Source: Field Survey/SPSS, 2022

Table 1b: T-test on Descriptive Statistics on Level of hazard vulnerability in relation to the extent of damages on lives, crops and roads in Minna

	Gender	Statistic	Std. Error
Level of hazard vulnerability in relation to the extent of damages on lives, crops and roads.	Males	Mean	11.1000
		95% Confidence Interval for Mean	.58595
		Lower Bound	9.7745
		Upper Bound	12.4255
		5% Trimmed Mean	11.0556
		Median	10.5000
		Variance	3.433
		Std. Deviation	1.85293
		Minimum	9.00
		Maximum	14.00
		Range	5.00

		Interquartile Range	2.75	
		Skewness	.605	.687
		Kurtosis	-.894	1.334
	Females	Mean	1.8000	.24944
		95% Confidence Interval for Mean	Lower Bound	1.2357
			Upper Bound	2.3643
		5% Trimmed Mean	1.7778	
		Median	2.0000	
		Variance	.622	
		Std. Deviation	.78881	
		Minimum	1.00	
		Maximum	3.00	
		Range	2.00	
		Interquartile Range	1.25	
		Skewness	.407	.687
		Kurtosis	-1.074	1.334

Source: Field Survey/SPSS, 2022

Table 1c: T-test on Independent Samples Test on Level of hazard vulnerability in relation to the extent of damage on lives, crops and roads in Minna

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Level of hazard vulnerability in relation to the extent of damage on lives, crops and roads	Equal variances assumed	7.494	.014	14.604	18	.000	9.30000	.63683	7.96206	10.63794
	Equal variances not assumed			14.604	12.158	.000	9.30000	.63683	7.91446	10.68554

Source: Field Survey/SPSS, 2022

Decision Rule: Reject H_0 if $\alpha=0.05$ is greater than the p-value = 0.000.

Conclusion: Since $\alpha=0.05$ is greater than the p-value = 0.000, There is a significant difference between male and female respondents on the level of hazard vulnerability in relation to the extent of damages on properties and infrastructure in Minna; therefore, the

null hypothesis is rejected.

H₀₂: There is no difference between males and females respondents on the measures necessary for mitigating disaster in Minna.

Table 1a: T-test on Case Processing Summary on measures necessary for mitigating flood disaster in Minna

	Gender	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Measures necessary for mitigating disaster in Minna.	Males	10	100.0%	0	0.0%	10	100.0%
	Females	10	100.0%	0	0.0%	10	100.0%

Source: Field Survey/SPSS, 2022

Table: 1b: T-test on Descriptive Statistics on Measures necessary for mitigating flood disaster in Minna

	Gender		Statistic	Std. Error
Measures necessary for mitigating disaster in Minna.	Males	Mean	11.6000	.63596
		95% Confidence Interval for Mean	Lower Bound	10.1614
			Upper Bound	13.0386
		5% Trimmed Mean	11.5556	
		Median	11.5000	
		Variance	4.044	
		Std. Deviation	2.01108	
		Minimum	9.00	
		Maximum	15.00	
		Range	6.00	
		Interquartile Range	3.50	
		Skewness	.279	.687
		Kurtosis	-.751	1.334
	Females	Mean	1.9000	.27689
		95% Confidence Interval for Mean	Lower Bound	1.2736
			Upper Bound	2.5264
		5% Trimmed Mean	1.8889	
		Median	2.0000	
		Variance	.767	
		Std. Deviation	.87560	

		Minimum	1.00	
		Maximum	3.00	
		Range	2.00	
		Interquartile Range	2.00	
		Skewness	.223	.687
		Kurtosis	-1.734	1.334

Source: Field Survey/SPSS, 2022

Table 1c: T-test on Independent Samples Test on Measures necessary for mitigating flood disaster in Minna

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Measures necessary for mitigating disaster in Minna.	Equal variances assumed	5.569	.030	13.985	18	.000	9.70000	.69362	8.24275	11.15725
	Equal variances not assumed			13.985	12.294	.000	9.70000	.69362	8.19272	11.20728

Source: Field Survey/SPSS, 2022

Decision Rule: Reject H_0 if $\alpha=0.05$ is greater than the p-value = 0.000.

Conclusion: Since $\alpha=0.05$ is greater than the p-value = 0.000, There is a significant difference between male and female respondents on the measures necessary for mitigating disaster in Minna; therefore, the null hypothesis is rejected.

Analysis of Variance

H_0 : There is no significant difference between the scenarios of predicting severe flooding in the area

Table 1d: Test of Homogeneity of Variances on Predicting scenarios of a severe flooding in Minna

Levene Statistic	df1	df2	Sig.
.125	2	27	.883

Source: Field Survey/SPSS, 2022

Table 1e: Test of Homogeneity of Variances on Predicting Scenarios of a flooding Disaster in Minna

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.267	2	.133	.035	.966
Within Groups	102.700	27	3.804		
Total	102.967	29			

Source: Field Survey/SPSS, 2022

Decision Rule: Reject H_0 if $\alpha=0.05$ is greater than the p-value = 0.966

Conclusion: Since $\alpha=0.05$ is not greater than 0.966., Analysis of variance in predicting scenarios of severe flooding in the Minna showed that the three scenarios of predicting flooding in Niger state were the same.



Plate I: Impact of River Sauke on Bangwa Gongwapi, Barikin sale, Saukakahuta and Sauke communities

Source: Researcher's work (2022)

People have been lured to floodplains since ancient times, first by the rich alluvial soil, later by the need for access to water supplies, water transportation, and power development, and later still as a relegated locus for urbanization, particularly for low income families. How the land is used and developed can change the risks resulting from floods. While some activities can be designed to mitigate the effects of flooding, many current practices and structures have unwittingly increased the flood risk.



Plate II: Trespassing on water drains in Bosso Community July 17th 2020

Source: Researcher's work (2022)

Conclusion

The outcome of the findings of the study showed and predicted that floods constituted an integral part of hazard vulnerability in Minna. However physical, social, environmental, and economic vulnerability indicators should all be considered in the suggested mitigation measures, which should be nationally relevant for all sorts of future disasters.

Recommendations

These include:

- Defending against future floods will therefore require more robust approaches to flood management that can cope with larger uncertainty or be adaptive to a wider range of futures. This could lead to a greater reliance on more flexible, incremental approaches to flood risk management, the incorporation of greater flexibility into the design of engineered measures, or acceptance of potential over-specification for inflexible measures.
- Agencies charged with the responsibilities of ensuring environmental sanitation in the state should ensure people living in urban areas of the State admonish the habit of cleaning culverts and drainages around their vicinities to avoid urban flooding. However, they should advise people in the urban areas and riverine communities of the state on the dangers of building on flood plains and indiscriminate dumping of refuse in drainages, culverts, and other waterways as a proactive measure to curb the flood menace.
- Finally, any effort at managing disaster must apply prevention strategies to reduce the impacts of natural and man-made disasters. We cannot decide how many storms will strike, or how fiercely the winds will blow, or the waters will rage. But we can decide - we must decide together - the impact they will have on our lives, property and on the ecosystem. This requires a collective approach by all stakeholders.

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